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Original Contribution

Studies on the Ozyorsk population: health effects

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Background

Over the last two decades, the public has become more concerned about the carcinogenic effects of exposure to environmental and occupational radiation at low doses and dose rates. Since the Chernobyl accident, one area of particular interest is the long-term health consequences from exposure to radioiodines. Such exposure can occur as a result of a nuclear accident, living in the proximity of a nuclear power or weapons plant, or fallout from nuclear weapons testing. In most western countries, doses from these sources have been relatively low, so that the statistical power of epidemiological studies often has not been sufficient to detect small health risks. In contrast, radiation exposures to several large populations in the former Soviet Union (FSU) have been substantial and the range of doses wide [1, 2].

The city of Ozyorsk (former Chelyabinsk-65) is located near the Mayak complex, the first Russian nuclear facility, which became operational in 1948. During the early years of Mayak's operation, when the filtration of nuclear releases was imperfect, the population of the city was exposed to environmental radiation from years of routine radioactive atmospheric emissions. Iodine-131 was the major radionuclide released into the atmosphere [1, 3]. This paper briefly summarizes current epidemiological studies evaluating health effects associated with the atmospheric discharges of radionuclides from the Mayak Production Association (MPA). A separate paper describes a proposed study to reconstruct individual radiation doses for the Ozyorsk population [3].

Aims of the study

A cohort of over 70,000 Ozyorsk residents, some of whom were exposed as children to high atmospheric discharges from the MPA and some of whom moved to Ozyorsk as children after the discharges were minimal, are currently under study (the Mayak Children's Cohort). Assessment of health effects, especially cancer and thyroid diseases, in this cohort can help fill gaps in what is known about protracted internal exposure from radioactive ^{131}I during childhood. The combination of large study size and a broad distribution of doses suggest that epidemiological studies conducted in this population would be informative about disease risks associated with low-dose protracted radiation. A key element in quantifying risks is the estimation of doses to the individuals under study. To date, such doses are not available, but since the methods for reconstructing individualized doses have been determined, they could be calculated if funding was provided (see [3]).

Description of the cohort

The Mayak Children's Cohort (MCC) is composed of 72,185 persons who lived in Ozyorsk for at least 1 year before they were 15 years of age. Of the cohort members, 78% were born in Ozyorsk between 1948 and 1988. The other cohort members were born elsewhere between 1934 and 1988, but moved to Ozyorsk before they were 15 years of age. Vital status at age 15 years is known for 63,253 (88%) of the cohort. This high follow-up rate enhances the value of the cohort for studying childhood cancers. Current vital status is known for 84% of the cohort members, however, the percentage with known vital status decreases with decreasing year of birth. The characteristics of the MCC are presented in Table 1.

Table 1. Selected characteristics of the Mayak Children's Cohort (MCC)

Details of MCC	Year of birth				Total
	1934-1947	1948-1959	1960-1973	1974-1988	
Number of persons [a]	5,504	25,984	19,632	21,065	72,185
Born in Ozyorsk[a] (%)[b]	0	21,651 (83)	16,609 (85)	17,822 (85)	56,082 (78)
Follow-up status as of age 15					
Known vital status (%)[b]	4,788 (87)	19,040 (73)	18,505 (94)	20,920 (99)	63,253 (88)
Number of person-years	31,652	240,937	246,690	272,799	792,070
Number of deaths	28	1,296	435	406	2,165
Cancer deaths	1	26	20	28	75
Leukemia deaths	1	14	7	10	32
Current follow-up status					
Known vital status (%)[b]	3,676 (67)	18,174 (70)	17,762 (90)	20,716 (98)	60,328 (84)
Number of person-years	189,431	777,689	589,783	373,253	1,930,156
Number of deaths	521	2,683	912	520	4,636
Cancer deaths	105	177	58	31	371
Leukemia deaths	5	25	12	11	53

[a]Excluding stillbirths

[b]Percentage of the total number of persons in the relevant birth cohort

Because the atmospheric releases of radionuclides were highest in the 1950s, children living in Ozyorsk during those years received substantial radiation exposure, particularly to the thyroid gland. Releases declined considerably after 1958, so that the environmental radiation exposure from Mayak was minimal after 1970 [1, 4].

Major results

Three endpoints are being evaluated in relation to radiation exposure in the MCC: mortality, thyroid cancer incidence, and thyroid disease in a screened subgroup of the cohort. To date, only results for thyroid cancer [5] and other thyroid diseases [6] have been analyzed.

Among a MCC subcohort of 20,083 individuals born between 1934 and 1966, and still living in Ozyorsk, thyroid cancer was diagnosed in 31 Ozyorsk residents between 1948 and 1998. The female-to-male ratio was close to 3:1 (24 women and 7 men), and papillary carcinomas occurred most frequently (22 cases), followed by follicular (8 cases), and anaplastic (1 case) carcinomas. These demographic and histological patterns are similar to those observed in other countries [7]. Thyroid cancer incidence in the MCC was 3-4 times higher than expected based on age, sex, and calendar year-specific Russian national thyroid cancer rates and 1.5- to 2-fold based on Chelyabinsk Oblast (regional) thyroid cancer rates. Slightly over 50% of the individuals who were diagnosed with thyroid cancer were born in 1948-1959, the period of highest radionuclide releases from the Mayak nuclear facility, compared with only 30% of the total cohort with known vital status. These preliminary results suggest an elevated risk of thyroid cancer among persons exposed to relatively high doses of protracted environmental ^{131}I [5].

In a pilot study, nearly 900 individuals still living in Ozyorsk underwent a special thyroid screening examination as part of their annual routine medical exam: 581 individuals were born and lived in Ozyorsk in 1952 and/or 1953 and, therefore, were exposed to relatively high levels of ^{131}I as very young children; 313 individuals were born elsewhere during the same 2 years and moved to Ozyorsk after 1967, thereby having little to no environmental radiation exposure. Thyroid disease (nodular goiter, autoimmune thyroiditis, diffuse goiter, benign tumor, and thyroid cancer) was diagnosed among 28% of the screened study participants. The prevalence of thyroid nodules was greater among exposed individuals (20.7%) than non-exposed (14.4%), largely due to a 70% increase in nodular goiter risk [6].

Problems, limitations, potential solutions

The studies of health effects associated with protracted environmental radiation among Ozyorsk residents are still in the early stages of development. The greatest limitation is the lack of dose estimates. Although age and years living in Ozyorsk can serve as a crude surrogate of dose, quantified risk estimates cannot be derived without doses. This problem could be resolved by undertaking a dose reconstruction project. This issue and a proposed solution are discussed in the accompanying paper on dosimetry [3]. An additional problem is finding an appropriate comparison population. If individual doses were available an internal analysis could be conducted and a comparison population would not be essential. However, at this time an external comparison group is necessary, but neither Russian national nor Chelyabinsk regional cancer incidence or mortality rates are adequate. Neither disease-specific nor cause-of-death-specific rates are available for all the years of follow-up, or for 5-year age groups. To help overcome the lack of sufficiently detailed data, rates were imputed based on cancer incidence trends from other countries and regions. Another limitation stems from incomplete follow-up. Current vital status is known for 70% of the cohort members born before 1960 compared with over 90% for those born after 1960. Since people born before 1960 received virtually all of the radiation exposure, this is an especially vexing problem. Attempts to improve follow-up are on-going and have been fairly successful over the last few years. If follow-up cannot be improved further, we may need to restrict our analyses of the total cohort to childhood mortality. A related limitation is that disease incidence data are collected by reviewing and abstracting medical records in the Ozyorsk clinics and the regional polyclinics. Thus, such information can be reliably obtained only for people still living in Ozyorsk. Finally, occupational radiation exposure can be an important confounding factor since many residents of Ozyorsk work at the Mayak nuclear facility. A unified occupational radiation database is currently under construction. When this database is completed, it will be possible to link members of the MCC to it to obtain their estimated occupational radiation doses.

Future plans

Studies of health effects in Ozyorsk residents have generally been pilot projects. Additional follow-up is necessary for older members of the MCC, doses or an improved proxy measure of exposure are needed, and more detailed statistical analyses must be completed. Analyses of thyroid disease, childhood cancer, reproductive variables, and mortality are planned for the near future, but to exploit this cohort fully, individual doses must be calculated for cohort members.

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